ORCHARD STUDIES: HOW LIGHT DENSITY IS AFFECTED BY USE OF FILLER TREES

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The usefulness of filler and semi-permanent trees in an apple orchard long has been the subject of argument and controversy. The chief mistake has been that such temporary trees have been left too long in the orchard thus leading to crowding, excess shade, poor yield, size, and color on lower branches, poor growth of mulch crops, and other difficulties.

In order that comparisons could be made between trees planted at the permanent distance of 35 feet and filler trees set at only half that space, an experimental orchard of the Haralson variety was planted at the Fruit Breeding Farm in the spring of 1932. Trees in the "Permanent" block were set on the square plan at 35 x 35 foot spacing. In the "Filler" block permanent trees were planted on the square at 35 x 35 feet in line with those in the "Permanent" block, Semi-permanent trees were set where diagonial lines between permanent trees intersected. These trees were spaced at approximately 25 feet from the permanent trees. Filler trees were set on the square and in line with permanent and semi-permanent trees. Spacing between all trees thus was 17.5 x 17.5 feet. Other studies were conducted in this orchard but this report deals only with the study of light intensities in the tree heads.

Investigations carried on elsewhere have shown how greatly light intensities are reduced within the head of a tree. In full sunlight light intensity is rated at 13,000 foot-candles. Instruments usually available for measurements of light intensities can record up to a maximum of 10,000 foot candles. At about 1,100 foot candles supposedly all the sugars manufactured in the leaves are used by a tree in growth or other life processes thus leaving no surplus for storage. This is known as the "Compensation Point". In many cases light intensities in the central and lower portions of a tree head are far below this point.

A study carried on in an Ohio orchard showed that light intensities in the center of tree heads frequently amounted to only one fourth of full sunlight (about 3250

foot candles). We can expect that light intensities will vary considerably with growth habit, head density, tree vigor, injuries, pruning treatment, etc. Some investigators have reported light intensities in the interior of dense head reduced to as little as 10 per cent of full sunlight (1,300 f.c.) and in extreme cases as low as one per cent (130 f.c.).

Light intensities are highest in mid-summer with the strongest light at mid-day on the south side of a tree. Brightly lighted clouds may add materially to light intensities by reflection.

As a general rule more fruit buds are formed in the well lighted parts of an apple tree. Experimental shading has reduced fruit bud formation to zero. It is well known that in the lower interior portion of an apple tree head fruit production is greatly reduced, size runs small, and color is poor. Partly because of these known effects of shade pruning practices have been developed such as "Thin Wood" pruning, thinning out to admit light, "Clover-leaf" or "Wedge", patterns etc. Hand thinning of the fruit according to the "Graduated Space" method also reflects the known reduction of light intensities in the interior of fruit tree heads.

Studies of light intensities in the heads of representative permanent trees in both permanent and filler blocks were carried on in the orchard at the Fruit Breeding Farm in the summer of 1947 when the trees were 16 years old. Records were made between 10 a.m. and 2 p.m. on June 24, June 27, and July 28 in full sunlight. On July 18 records were made under complete overcast. Light intensities were recorded by a Weston Illuminometer at a uniform height of one foot from the ground. Records were made at eight points in each of three circles at 3, 6 and 9 feet from the trunks and at the center point on the south side of the trunks.

In the "Permanent Spacing" block at 16 years of age the space between trees was wide, so all the outer portions of these tree heads were exposed to full sunlight sometime during the day. This condition is shown graphically in the accompanying figure. The "Filler Block" trees, spaced only 17.5 feet apart, had crowded so much by the 16th year that their branches grew together, or interlaced, an average

of two feet along the rows and many trees interlaced as much as four feet. Thus there was no unoccupied space between the trees in either North-South or East-West directions. The only unoccuped spaces in the "Filler Block" were small openings in the middles of the squares. These small openings rarely were larger than five to seven feet in greatest diameter. Crowding of the "Filler" trees is shown graphically in the accompanying figure.

In general there was little difference between trees in the "Permanent Spacing" compared to "Fillers" relative to light intensities in the heads of the trees. In either case light intensities dropped rapidly as sooh as recording instrument was moved into the shaded outer portions of the tree heads. Within the outer three or four feet of the heads, as measured a foot from the ground, light intensities fell from the 13,000 f.c. of full sunlight to between 2,500 and 8,000 f.c. depending upon density of the heads. Variations were due to pruning, tree vigor, winter injury, or breakage. Under comparable conditions light intensities in the "outer shell" of the heads averaged about 3,500 f.c. The accompanying figure shows how light intensities probably are decreased throughout the tree heads.

In the inner central portions of the tree heads, where shade was heavier, light intensities dropped to 1,600 f.c. or lower. In some cases intensities as low as 500 f.c. were recorded. These variations again were due to pruning treatment, tree vigor, injuries, etc. In many cases intensities in this portion of the tree heads were considerably below the "Compensation Point" at 1,100 f.c.

In the heavy shade in the central portion of the heads close to the trunk light intensities rarely were as high as 1,000 f.c. and often fell as low as 300 f.c. In this portion there is, of course, the cumulative effect of shading from all higher parts of the heads.

The principal difference between trees in the "Filler Block" and those in the "Permanent Spacing Block" was the interlacing of branches of the filler trees. Due to this interlacing of two to four feet shade was continuous along and across the rows so that full sunlight could not reach the lower outer portions of the heads except in the very limited areas in the centers of the squares. As shown in

the figure, light intensities throughout most of the heads of trees in the "Filler Block" fell into Class 3 ranging between 500 and 1,600 f.c. Thus the better lighted "outer shell" of the heads was materially reduced to the disadvantage of tree performance. In the "Permanent Space Block" all of the "outer shell" of the trees was exposed to full sunlight for at least part of the day.

The low light intensities in the lower portions of the tree heads appear to be closely associated with the development of "Thin Wood", poor bud formation, and with the poor size and color of the fruit produced in that portion. Obviously it will be the best practice to prune out "Thin Wood" and in many cases to follow the old time practice of pruning to open the heads somewhat so that light can penetrate deeper within the tree. In dense heads it may be desirable to open up three or four "lanes" into the center thereby not only admitting more light, but also making spraying and harvesting easier.

Of course some items other than light need to be considered relative to use of fillers. Roots are known to spread several foot beyond the tips of the branches. Therefore roots will crowd long before the branches interlace. When the roots are crowded there will be severe competition in the soil for water and mineral foods to the detriment of the trees. Minnesota, in general can be classed as a "Marginal Area" in relation to rainfall occurring during the growing season. In the Twin City area average rainfall during 50 growing seasons from April to October has amounted to about 20 inches. This is only slightly more than the 18 inches said to be the minimum requirement for good performance of an apple tree. When fillers are left in too long competition for water may seriously affect the trees. It is desirable not only to know how light conditions vary within tree heads but also to "look beneath the surface" to picture root distribution and the competition for mineral foods and water.

In conclusion, it can be said that filler trees should be used only where there is a full understanding of their effects upon mineral foods, water and on light conditions. Also, to use semi-permanent trees will double planting costs, and when both semi-permanent and filler trees are used planting costs will be quadrupled. To

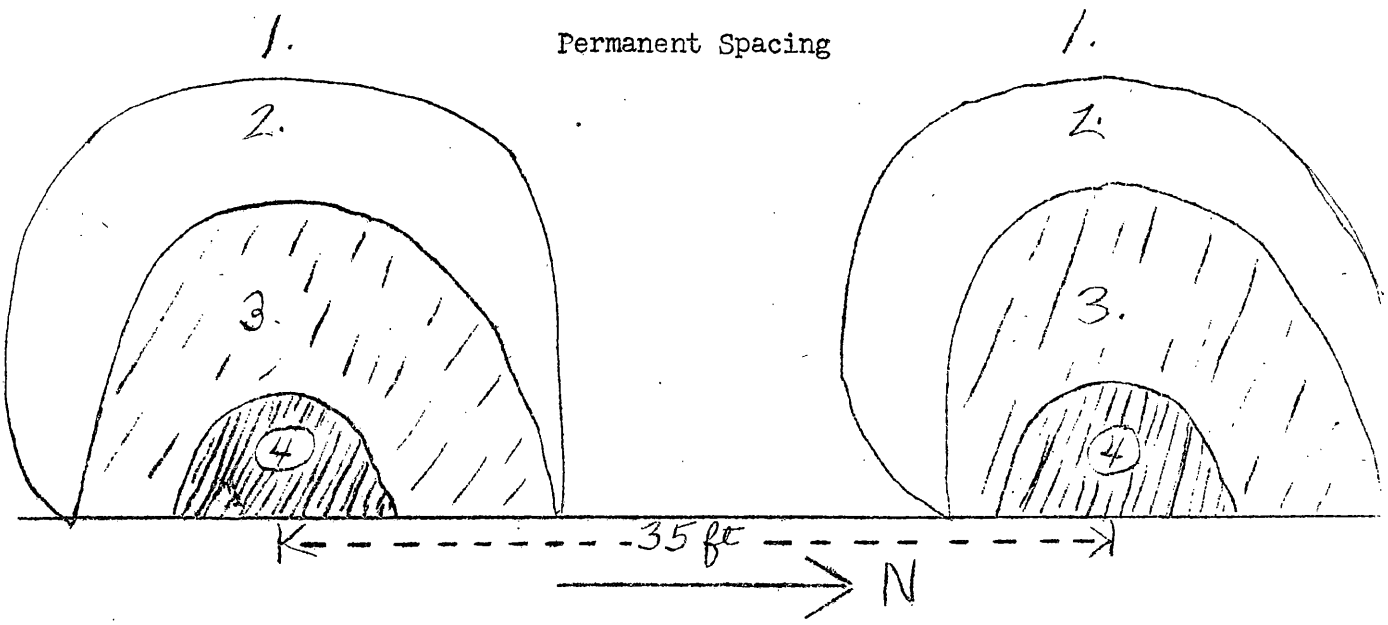
offset these additional costs, yields during the first twelve to fourteen years should be greatly increased. The "Filler Block" of Haralson trees at the Fruit Breeding Farm produced a crop of over 1200 bushels per acre in the 12th year. When land costs are not high it may be best not to use fillers because of the very common tendency to leave them in too long. With the Haralson variety, or others that do not make a very large tree, use of semi-permanent trees at about 25 foot spacing may give good performance for 25 years or longer.

Note: Earlier contributions in this series of Orchard Studies were as follows:

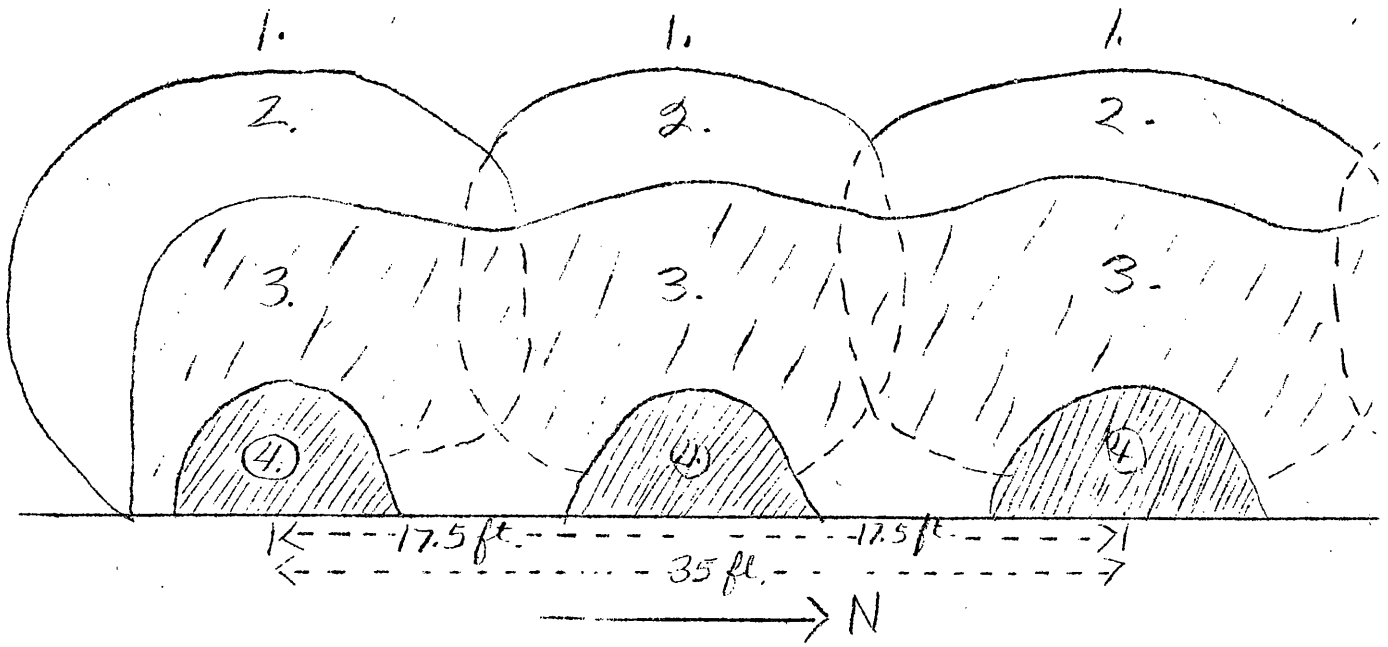
1. The relation of tree vigor to the rate of healing of pruning wounds in the Apple Proc. Am. Soc. Hort. Sci. 29 (1932): 90-92. 1933.
2. Twelve year production record of the experimental orchard at the Fruit Breeding Farm. Mimeographed report. 1944.
3. Clustering habit in Wealthy, Haralson and Minjon apples. Minn. Hort. 73: 74-75. May 1945.
4. The clustering habit in Haralson, Minjon and Wealthy Apples. Proc. Am. Soc. Hort. Sci. 50: 17-20. 1947.
5. Thinning apples with blossom sprays. Minn. Hort. 72: 52-53. 1950.
6. Chemical thinning of apples. Mimeographed report. March, 1952.
7. Chemical thinning of apples in 1952. Mimeographed report. November, 1952;

A few copies of some of the above are available at the Department of Horticulture, University Farm, St. Paul 1, Minnesota.

Permanent Spacing



Filler Spacing



1 = Full sunlight 13,000+ foot candles

2 ="Outer shell" of trees 2,500 to 8,000 foot candles

3 = Shaded centers 500 to 1600 foot candles

4 = Heavy shade 300 to 1000 foot candles

"Compensation Point" 1100 foot candles